



Research Department Report

METAL-FRAMED PARTITIONS WITH REDUCED THICKNESSES: Part 1 – Narrower studs and cavities

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Summary

The sound insulations were measured, in the Research Department Transmission Suite, of ten different metal-framed partitions. These partitions had narrower cavities and metal studs than those of the conventional thickness metal-framed Camden. Mineral wool had been installed in the cavities of some of the partitions and some partitions had double plasterboard skins rather than plasterboard-fibreboard skins.

The sound insulations of these narrow partitions were generally comparable with, or marginally higher than, those of similar partitions, having stud and cavity widths equal to those in the conventional thickness metal-framed Camden. However, the loadbearing capabilities must be investigated before these narrow partitions can be recommended as alternatives to the conventional thickness metal-framed Camden. The use of these narrow partitions should result in average increases, of approximately 8%, in the available floor areas of typical studios.

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1. INTRODUCTION

The 'Camden' is a lightweight partition that, in a timber-framed form, has seen widespread use in studio construction throughout the BBC. It has a high sound insulation performance for its mass. Recent studies have shown that the timber studs of the Camden can be replaced by proprietary metal studs (from Redland Plasterboard), to reduce construction costs. The resulting metal-framed Camden has a slightly higher sound insulation than the equivalent timber-framed Camden.

One comment that is often made by BBC Architects is that the overall thicknesses of these types of lightweight partitions are quite large (a timber-framed or metal-framed triple Camden, with conventional BBC modular acoustic treatment fitted on both sides, has a thickness of approximately 0.9 m). With narrower partitions between the studios, the available floor areas would be greater.

A companion Report¹ describes an investigation of the feasibility of building the studio acoustic treatment into metal-framed partitions. In assessing partitions with built-in acoustic treatment, some factors that must be considered are the overall cost of construction, the achievable levels of sound insulation and the flexibility of the acoustic design. (In the past, modular acoustic treatment has proved to be very worthwhile, as it allows the level of treatment to be tailored to the particular needs of different studio areas.)

In contrast, the purpose of the work described in this Report was to investigate the effects on the measured sound insulations, of reductions in the thicknesses of metal-framed partitions.

2. FACTORS AFFECTING THE SOUND INSULATION

The sound insulation performances of partitions are usually degraded by reductions in their thicknesses, a factor that may be acceptable in circumstances where floor space would have a greater priority than absolute values of sound insulation. However, it was desirable to minimise the differences between the sound insulations of any proposed narrow partitions and those of the conventional thickness partitions.

Reductions in the thicknesses of metal-framed

partitions should not significantly affect the sound insulations of the partitions at lower frequencies. This is because the masses of the narrow partitions would be essentially the same as the masses of the corresponding conventional thickness partitions. For this assumption to be valid, the internal damping in the partition and its internal resonances must not be altered greatly by a reduction in thickness.

The sound insulations of metal-framed partitions, at higher frequencies, should decrease as the thicknesses of the partitions are reduced. This is because reducing the widths of the cavities increases the coupling, by the air in the cavities, between the boards of the partitions. For this assumption to be valid, the air in the cavities, rather than the metal studding, must be the dominant cause of the coupling between the boards on either side of the cavity.

Two ways of restoring the sound insulations of the reduced thickness partitions were therefore to be investigated; the installation of mineral wool in the cavities of the partitions and the use of additional layers of plasterboard. Firstly, worthwhile increases in the sound insulations of timber-framed² and metal-framed³ Camdens have been shown to result from the installation of mineral wool in the cavities of the partitions. The mineral wool acoustically treats the cavities of the partitions and absorbs some of the sound that has been transmitted into the cavities. Secondly, the overall masses of lightweight partitions are increased by the use of additional layers of plasterboard. This should increase the sound insulations of the partitions, particularly at lower frequencies (whereas the installation of mineral wool in the cavities does not significantly alter the sound insulations at lower frequencies).

3. PRACTICAL DETAILS AND LIKELY DIMENSIONAL BENEFITS

The narrowest studs that Redland Plasterboard manufacture⁴ were selected for the construction of the narrow partitions. The width of the narrow metal C studs (type CS50/R) is 50 mm (compared to 70 mm for the C studs in the conventional thickness partition). These C studs are used in single leaf partitions, or in the first leaves of double or triple leaf partitions. The width of the metal Shaftwall studs (type CHS63/W) is 63 mm (compared to 102 mm for the Shaftwall studs in the conventional thickness partitions). The

Shaftwall studs are used in the second leaves of double leaf partitions and in the second and third leaves of triple leaf partitions.

A multi-leaf method of construction was to be retained (rather than using thick, massive single leaf partitions), as mechanically independent leaves have high sound insulations in relation to the overall masses and thicknesses of the partitions. With multi-leaf partitions, ‘box-within-box’ studios can be constructed, in which separate rooms are independently floated. However, the widths of the cavities between leaves were reduced from 50 mm to 30 mm (there would be a risk of the leaves of the partition becoming coupled during construction if the widths of the cavities were less than 30 mm). Table 1 shows the thicknesses of the narrower partitions compared with those of the conventional thickness Camdens (the depth of the acoustic treatment is *not* included).

Table 1: Overall partition thicknesses.

Thickness (mm)	Using narrower metal studs	Using usual metal studs
Single leaf partition	100	120
Double leaf partition	218	297
Triple leaf partition	336	474

Consider a typical studio, with a floor size of 3 m by 4 m, having an associated sound control room with a floor size of 4 m by 5 m. The total available floor area, for both of the rooms and the partitions, is constant. The partitions are of double leaf construction, apart form the partition separating the two studio areas (length 4 m), which is of triple leaf construction. The approximate savings in the available floor areas, resulting from the use of the narrow partitions are:

Sound control room	7%
Studio	9%

The measurements described in this Report do not include sound insulation measurements on triple leaf partitions, as it is difficult to mount, independently, three leaves in the test aperture of the Transmission Suite. However, the relative performances of triple leaf partitions can, to some extent, be predicted from the results of the measurements on the single and double leaf partitions.

For reference, Fig. 1 shows the symbols used in the keys to all the subsequent measurement graphs.

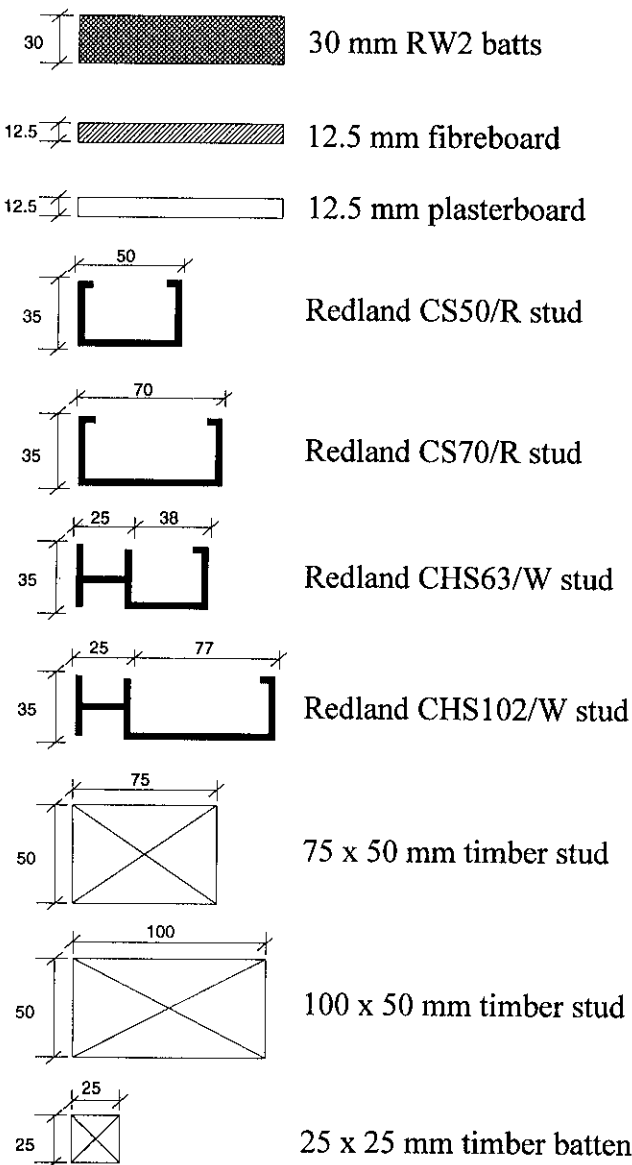


Fig. 1 - Symbols used in the keys for the graphs.

4. PARTITIONS CONTAINING PLASTERBOARD AND FIBREBOARD

4.1 Single leaf partitions

Fig. 2 shows the sound insulation curve, for a single leaf partition, using 50 mm studs, clad on both sides with one layer of fibreboard and one layer of plasterboard. The sound insulation curve is compared with that for a similar partition using 70 mm studs (metal-framed single Camden) and with that for a timber-framed single Camden. The differences between the sound insulation curves of the two metal-framed partitions are small; the sound insulation of the partition using 50 mm studs is marginally higher, at most frequencies, than that for the partition using 70 mm studs. Above 160 Hz, both metal-framed partitions have higher sound insulations than the single Camden.

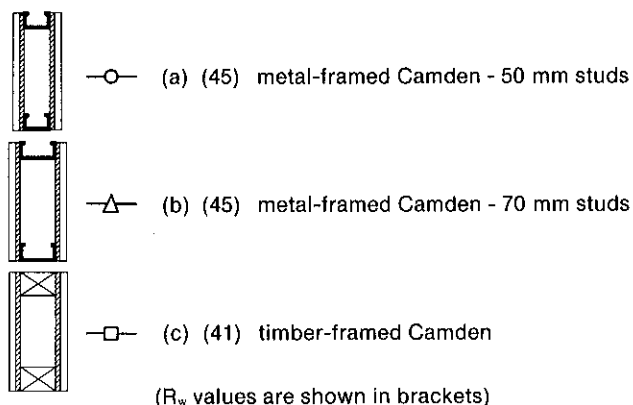
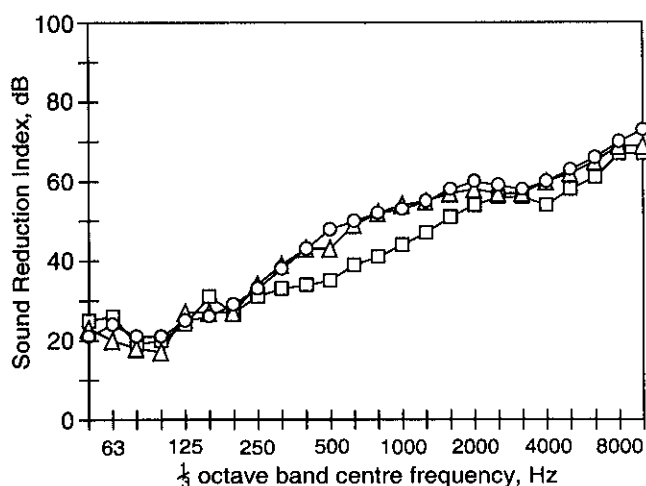


Fig. 2 - The sound insulations of single leaf partitions.

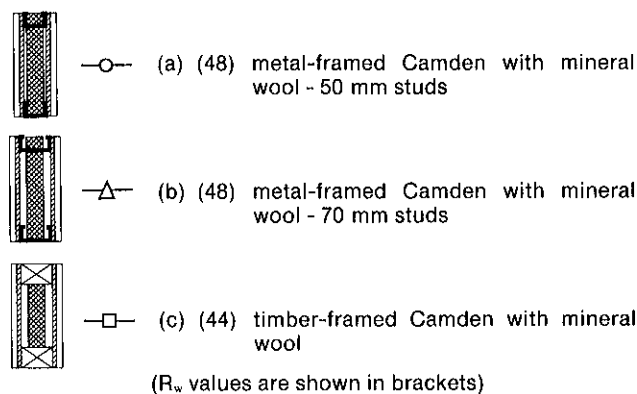
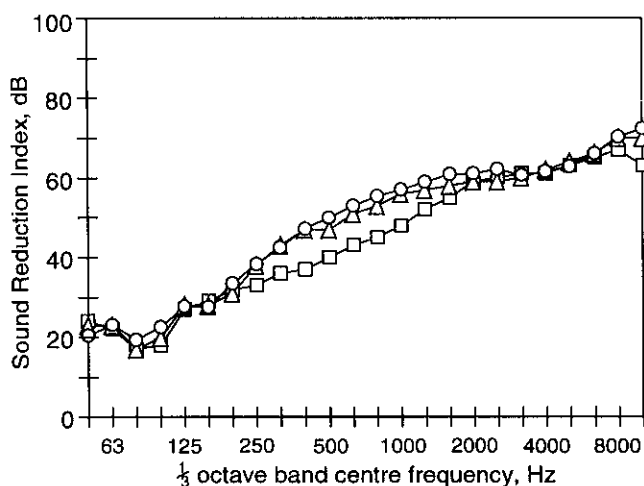


Fig. 3 - The sound insulations of single leaf partitions.

It is, perhaps, surprising that reducing the width of the metal studs results in an increase in the measured sound insulation. There were no differences in the construction standards for the two metal-framed partitions. The studs probably produce most of the coupling between the two plasterboard-fibreboard layers, rather than the air in the cavities of the leaves. There is evidence for the validity of this statement in that there are quite large differences, above 200 Hz, between the sound insulation curves for Fig. 2(b) and Fig. 2(c), but the only difference, between the two partitions corresponding to these curves, is in the material from which the studs were made (the widths of the cavities are the same). Thus, within reason, the width of the airspace will not be important because the studs determine the coupling. The 50 mm steel studs seemed to be slightly more flexible than the 70 mm steel studs, which might explain why the measured sound insulation was slightly higher when using 50 mm, rather than 70 mm studs.

Fig. 3 shows the sound insulations of single leaf partitions with mineral wool in the cavities. As before, the sound insulation curve of the partition using 50 mm studs is very similar to the curve for the partition using 70 mm studs. Both metal-framed partitions have significantly higher sound insulations,

between 200 Hz and 2 kHz, than the timber-framed single Camden with mineral wool.

4.2 Double leaf partitions

In Fig. 4, the sound insulation of a narrow version of the metal-framed double Camden is compared with the sound insulation of the metal-framed double Camden. The cavity between the two independent leaves of the narrow partition was 30 mm wide (rather than 50 mm, as in the conventional metal-framed double Camden). The sound insulation of a timber-framed double Camden is also shown for reference. The sound insulation of the narrow partition is significantly lower than the sound insulation of the conventional metal-framed Camden, between 200 - 315 Hz and between 1.6 - 2 kHz. Otherwise these two metal-framed partitions have comparable sound insulation performances.

The lower performance of the narrow partition, between 200 Hz and 315 Hz, is important. There are two possible causes for this lower performance. Firstly, the dip at 200 Hz in the sound insulation curve of the narrow partition could have been caused by some resonance in the partition, which was related to the widths of the cavities and the studs. Secondly, the dip

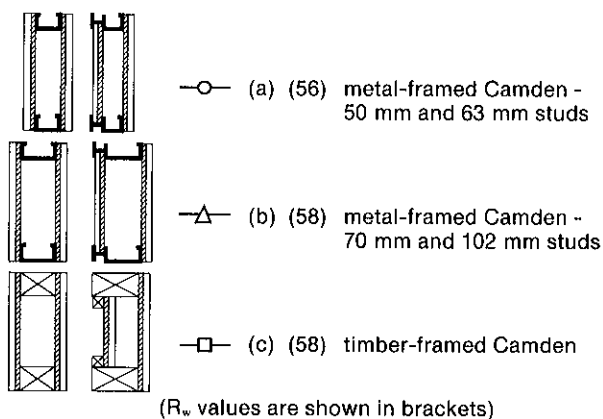
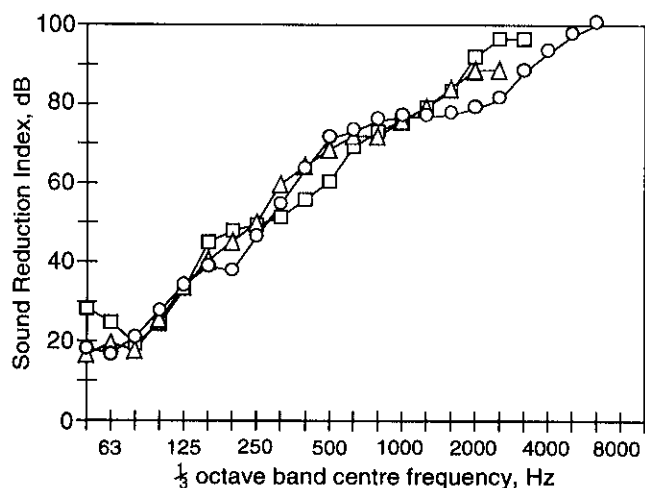


Fig. 4 - The sound insulations of double leaf partitions.

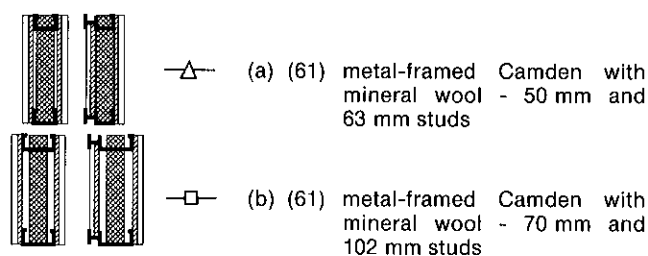
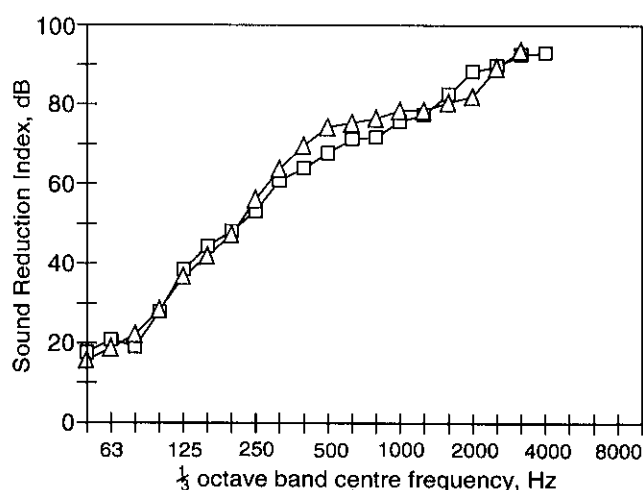


Fig. 5 - The sound insulations of double leaf partitions.

at 200 Hz could have been caused by some defect in the construction of the narrow partition. There was some suspicion at the time of construction that insufficient acoustic sealant had been used in some of the joints of the partition — a defect that was not repeated in the other partitions. This might have created 'holes', or acoustic weaknesses, which would allow sound to leak through the partition. 'Holes' often produce sharp dips like this in the sound curves of partitions.

As none of the other double leaf partitions tested showed a similar dip (in particular, there was no dip in the sound insulation curve for the narrow, metal-framed double Camden with mineral wool), the second possible cause was more likely, i.e. the dip at 200 Hz was probably caused by some construction defect. Had this defect not occurred, the sound insulation performance of the narrow metal-framed double Camden might have been similar to that of the conventional thickness metal-framed double Camden.

Fig. 5 shows the sound insulation of a narrow metal-framed double Camden, with mineral wool in the cavities, compared with the sound insulation of a similar conventional thickness partition. The sound insulation of the narrow partition is higher, between

250 Hz and 1.25 kHz, than that of the conventional thickness partition; but the narrow partition has a lower sound insulation at 2 kHz. At other frequencies, the sound insulations of the two partitions are very similar.

Though initially surprising, it is perhaps understandable how much higher the sound insulation of this narrow partition is, at mid frequencies, than the sound insulation of its conventional thickness counterpart. It can be assumed, from the results shown in Fig. 3, that the sound insulations of both of the leaves of the narrow partition, measured independently, should be marginally higher than the sound insulations of the corresponding conventional thickness leaves. Also, the two leaves of the narrow partition would have internal resonant frequencies which differed more from each other, than did the resonant frequencies for the two leaves of the conventional thickness partition (because the cavity widths are more dissimilar for the two leaves of the narrow partition). Therefore the sound insulation should be higher for the narrow partition.

Fig. 6 shows the effects of installing an extra layer of mineral wool between the two leaves of the narrow partition having mineral wool in those leaves.

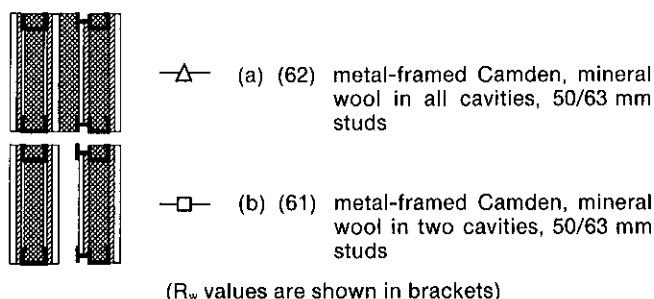
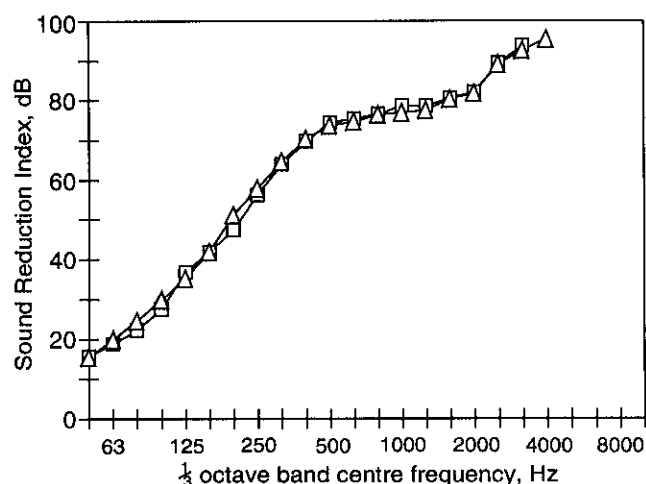


Fig. 6 - The sound insulations of double leaf partitions.

The two sound insulation curves show very close agreement. This shows that an additional layer of mineral wool, in the cavity between the two leaves, is superfluous.

5. PARTITIONS CONTAINING DOUBLE LAYERS OF PLASTERBOARD

At the planning stage for these narrow partition tests, the intention was to design narrower partitions with acceptable levels of sound insulation. The sound insulations of the partitions were expected to reduce as the thicknesses of the partitions were reduced. It was envisaged that some means would be required to return the sound insulations to satisfactory levels. One method for increasing the sound insulation (already described), was to introduce mineral wool into the cavities of the partitions. Another possible method, was to increase the mass of the partition. The masses of these lightweight partitions could be increased easily by adding extra layers of plasterboard. However, this would increase the thicknesses of the partitions and would clearly increase the construction costs, which was undesirable. Therefore, all of the fibreboard layers in the previously tested narrow partitions were replaced by plasterboard, which resulted in partitions with only double plasterboard layers. All of the measurements were then repeated.

These double plasterboard partitions should have the same overall thicknesses and approximate construction costs as those of the narrow plasterboard-fibreboard partitions. The double plasterboard partitions are more massive; thus though they should have higher sound insulations, particularly at lower frequencies, without the fibreboard, there would be less damping of the motion of the boards. This might cause a reduction in the sound insulation performances, particularly at higher frequencies. A direct comparison of simple plasterboard-fibreboard and double plasterboard partitions has not previously been performed, so these studies were expected to provide valuable new information.

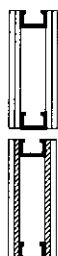
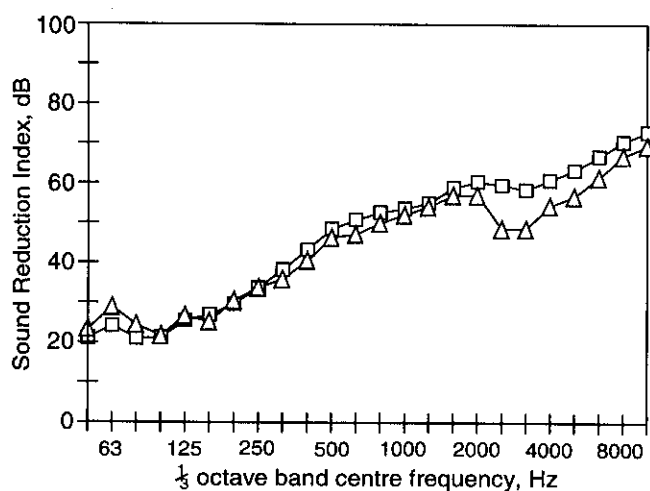
5.1 Single leaf partitions

Fig. 7 (*overleaf*) shows the sound insulation of a narrow, single leaf partition, using double layers of plasterboard, compared with the sound insulation of a similar partition using plasterboard-fibreboard layers. The double plasterboard partition has a higher sound insulation, between 50 and 80 Hz, but its performance is lower above 250 Hz. The low frequency sound insulation of the double plasterboard partition is higher because of the greater mass of the partition. However, the sound insulation at higher frequencies is relatively lower, because the plasterboard sheets are less heavily damped. These results show that damping effects can be more important than mass effects in certain single leaf partitions. The dip in the sound insulation curve, at 2.5 - 3.15 kHz, for the double plasterboard partition, is caused by *wave coincidence*⁵.

Fig. 8 (*overleaf*) shows the sound insulations of single leaf partitions similar to those in Fig. 7, except that mineral wool has been installed in the cavities. In this case, the sound insulation of the double plasterboard partition, up to 500 Hz, is higher than that of the plasterboard-fibreboard partition; above this frequency, the converse is true (the mineral wool has only a small effect on the depth of the coincidence dip). The relative performance of this double plasterboard partition (to the performance of the plasterboard-fibreboard partition with mineral wool) is better than the relative performance of the double plasterboard partition without mineral wool (to that of the plasterboard-fibreboard partition without mineral wool). It is possible that this is because the mineral wool in the cavity damps the motion of the plasterboard, in addition to absorbing some of the sound that has leaked into the cavity.

5.2 Double leaf partitions

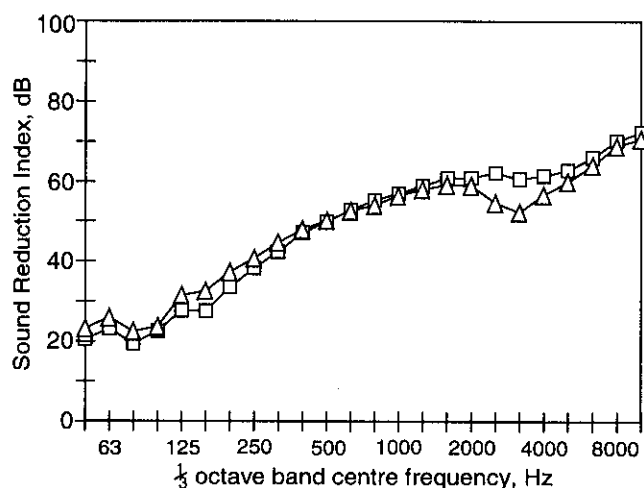
Fig. 9 (*overleaf*) shows the sound insulation of a narrow double-leaf partition, using double plasterboard layers, compared with the sound insulation of



- △— (a) (45) double plasterboard partition
50 mm studs
- (b) (45) metal-framed Camden - 50 mm
studs

(R_w values are shown in brackets)

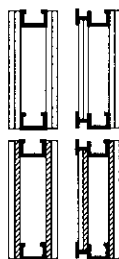
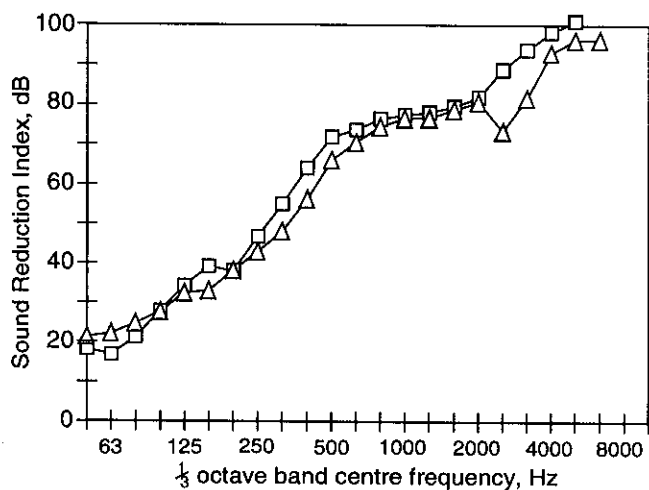
Fig. 7 - The sound insulations of single leaf partitions.



- △— (a) (51) double plasterboard partition with
mineral wool - 50 mm studs
- (b) (48) metal-framed Camden with mineral
wool - 50 mm studs

(R_w values are shown in brackets)

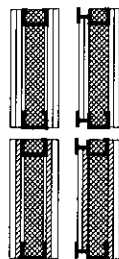
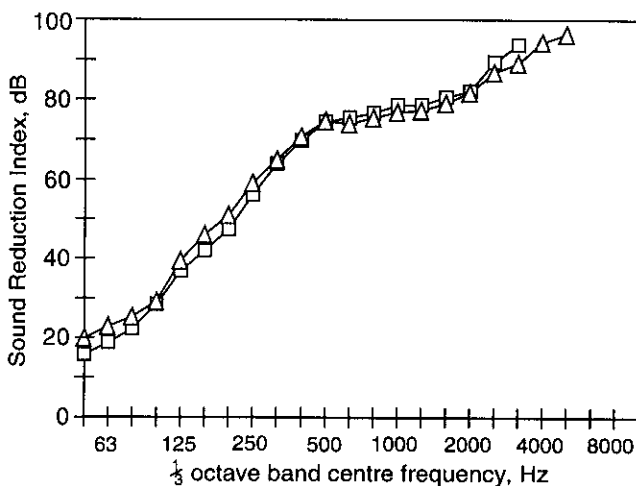
Fig. 8 - The sound insulations of single leaf partitions.



- △— (a) (53) double plasterboard partition -
50 mm and 63 mm studs
- (b) (56) metal-framed Camden - 50 mm
and 63 mm studs

(R_w values are shown in brackets)

Fig. 9 - The sound insulations of double leaf partitions.



- △— (a) (63) double plasterboard partition,
mineral wool - 50 mm and
63 mm studs
- (b) (61) metal-framed Camden with
mineral wool - 50 mm and
63 mm studs

(R_w values are shown in brackets)

Fig. 10 - The sound insulations of double leaf partitions.

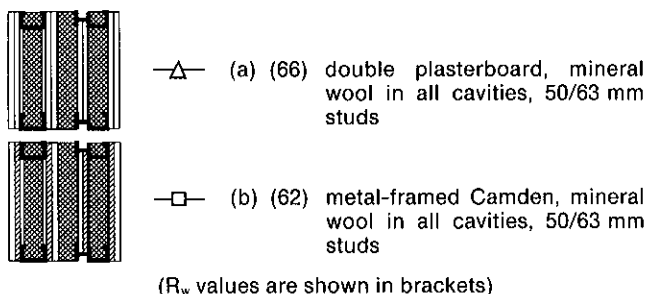
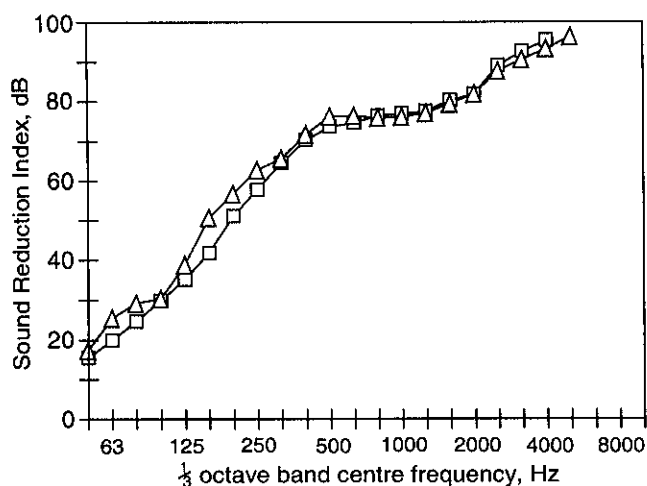


Fig. 11 - The sound insulations of double leaf partitions.

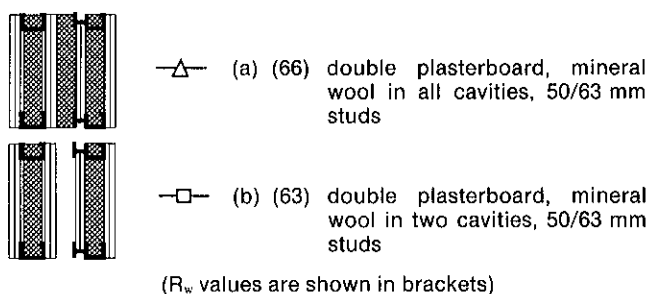
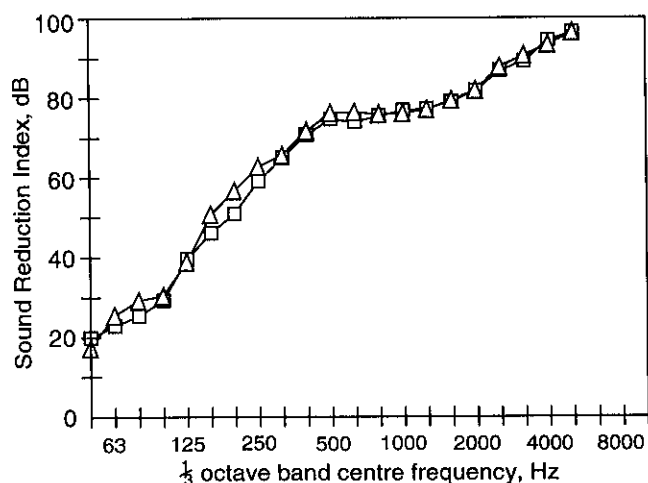


Fig. 12 - The sound insulations of double leaf partitions.

the corresponding partition using plasterboard-fibreboard layers. The double plasterboard partition has a lower sound insulation at all frequencies, other than from 50 Hz to 80 Hz. This observation is similar to that made for the single leaf partition (Fig. 7).

Fig. 10 shows the corresponding sound insulations for partitions similar to those in Fig. 9, except that mineral wool has been inserted into the cavities in the leaves. As for the similar type of single leaf partition (Fig. 8), the sound insulation of the double plasterboard partition is higher up to 500 Hz; above this frequency, the converse is true. Similar reasons to those given in Section 5.1 can be used to explain why the relative performances of double leaf, double plasterboard partitions (to those of double-leaf plasterboard-fibreboard partitions) are better when mineral wool has been installed in the cavities.

Fig. 11 shows the sound insulation of a double leaf, double plasterboard partition with mineral wool in both the cavities of the leaves and in the cavity between the two leaves. This sound insulation is compared with the sound insulation of a similar partition using plasterboard-fibreboard layers. The sound insulation of the double plasterboard partition is higher, up to 630 Hz, than that of the plasterboard-fibreboard partition. Above this frequency, the differences between the two curves are small. The double plasterboard partition is obviously preferable to

the plasterboard-fibreboard partition, on sound insulation grounds, although weight restrictions might affect the choice of partition for a particular studio area.

As an aside, Fig. 12 shows the sound insulations of the double leaf, double plasterboard partition, with mineral wool either in both the cavities of the leaves and the cavity between the leaves, or in both the cavities of the leaves but not in the cavity between the two leaves. In marked contrast to the result for the plasterboard-fibreboard partitions (Fig. 6), the sound insulation is generally higher for the partition with the additional layer of mineral wool. This may be because the extra layer of mineral wool provides further damping to the motion of the layers of double plasterboard. (In the plasterboard-fibreboard partition, the fibreboard provides the majority of the damping of the plasterboard.) The results of Fig. 12 show that mineral wool should be installed in all three cavities of double leaf, double plasterboard partitions, despite the marginal extra cost.

6. DISCUSSION

By comparing the individual comments made in each Section, on the sound insulation performances of the narrow partitions, the following overall comments can be made on the various partitions.

Fig. 2(a)

This partition is the cheapest and is acceptable on sound insulation grounds, for situations where a lightweight partition would usually be used. However, the partition shown in Fig. 3(a) has a higher sound insulation, with only a marginal increase in cost.

Fig. 3(a)

This partition is a good compromise on cost, thickness and sound insulation, for a single leaf partition. The partition of Fig. 8(a) may, however, be preferable on sound insulation grounds. It has a higher sound insulation at lower frequencies, at the cost of a lower sound insulation at higher frequencies (see also the comments on the partition of Fig. 2(a)).

Fig. 4(a)

This partition is the cheapest double leaf partition. It is acceptable on sound insulation grounds. However the partition shown in Fig. 5(a) may be preferable as it has a higher sound insulation at only a marginally higher cost.

Fig. 5(a)

This partition is a good compromise on sound insulation and cost, for a double leaf partition. However the partition of Fig. 11(a) may be preferable, as it has a higher sound insulation, although it is slightly more expensive (see also the comments on Fig. 4(a)).

Fig. 6(a)

This partition should not be used as it is more expensive than that of Fig. 5(a) and it does not have a concomitantly higher sound insulation.

Fig. 7(a)

This partition should not be used as it has a lower sound insulation than that of Fig. 2(a), without costing or weighing any less.

Fig. 8(a)

This partition is a good compromise on cost and sound insulation for a single leaf partition (see also the comments for Fig. 3(a)).

Fig. 9(a)

This partition should not be used as it has a lower sound insulation than that of Fig. 4(a), without costing or weighing any less.

Fig. 10(a)

This partition should not be used, as it has a lower sound insulation than that of Fig. 11(a) and it is only marginally cheaper.

Fig. 11(a)

This partition is the heaviest and most costly (although not by a significant amount), but it has the highest sound insulation. Therefore it should be used where the sound insulation requirements necessitate a lightweight partition with the highest possible sound insulation.

7. CONCLUSIONS

The sound insulations were measured of a number of metal-framed partitions, which had narrower studs and cavities than those of other metal-framed partitions that have previously been measured. Generally, the sound insulations of these narrow partitions were marginally higher than the sound insulations of similar partitions with more conventional thicknesses.

A number of partitions were also tested, which used the narrow studs, but which had double layers of plasterboard, rather than combined plasterboard-fibreboard layers. These double plasterboard partitions generally had relatively higher sound insulations at lower frequencies (because of mass effects) and relatively lower sound insulations at higher frequencies (because of reduced damping effects). In this Report, the suitability is discussed, on sound insulation grounds, of each partition tested, for use in studio construction.

8. RECOMMENDATIONS

Before the narrow partitions can be recommended as alternatives to the conventional thickness partitions, the structural loadbearing capabilities of these partitions must be investigated by a structural engineer. Such studies must include the structural strength and reliability of joints, corners and other details, for which the tolerances will be more critical than for the conventional thickness partitions.

Existing constructional details for doors and observation windows might have to be altered. Additional stiffening may be required to support the weight of acoustic doors. Also, the panes of observation windows might have to be built out from the partitions. The sound insulations of the windows would be compromised if adequate cavity widths were not maintained.

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